



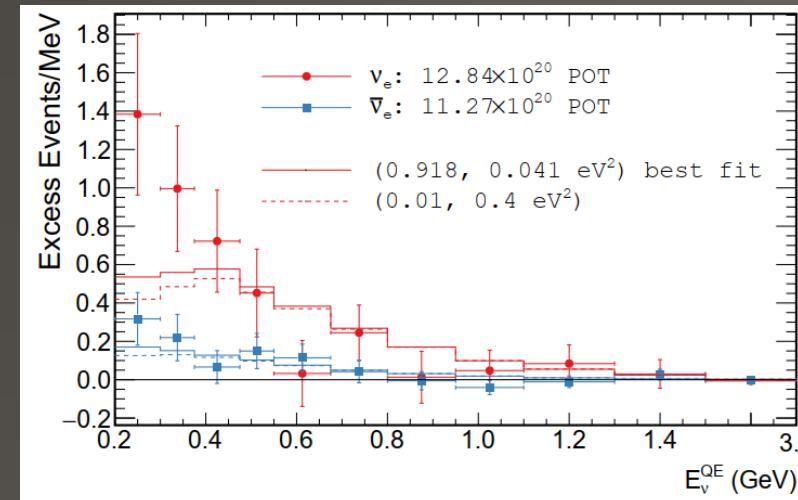
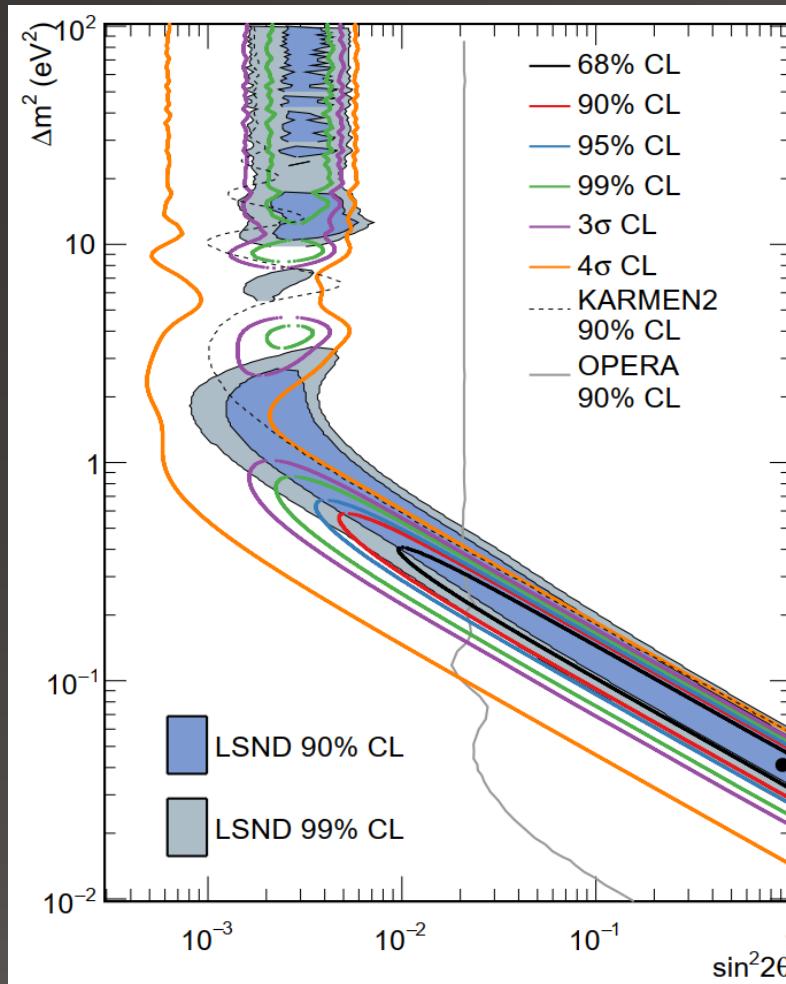
Constraining Sterile Neutrino Interpretations of the LSND and MiniBooNE Anomalies with CEvNS Experiments

arXiv:1901.08094

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LSND, and MiniBooNE Anomalies



Aguilar-Arevalo et. al. (MiniBooNE), arXiv: 1805.12028

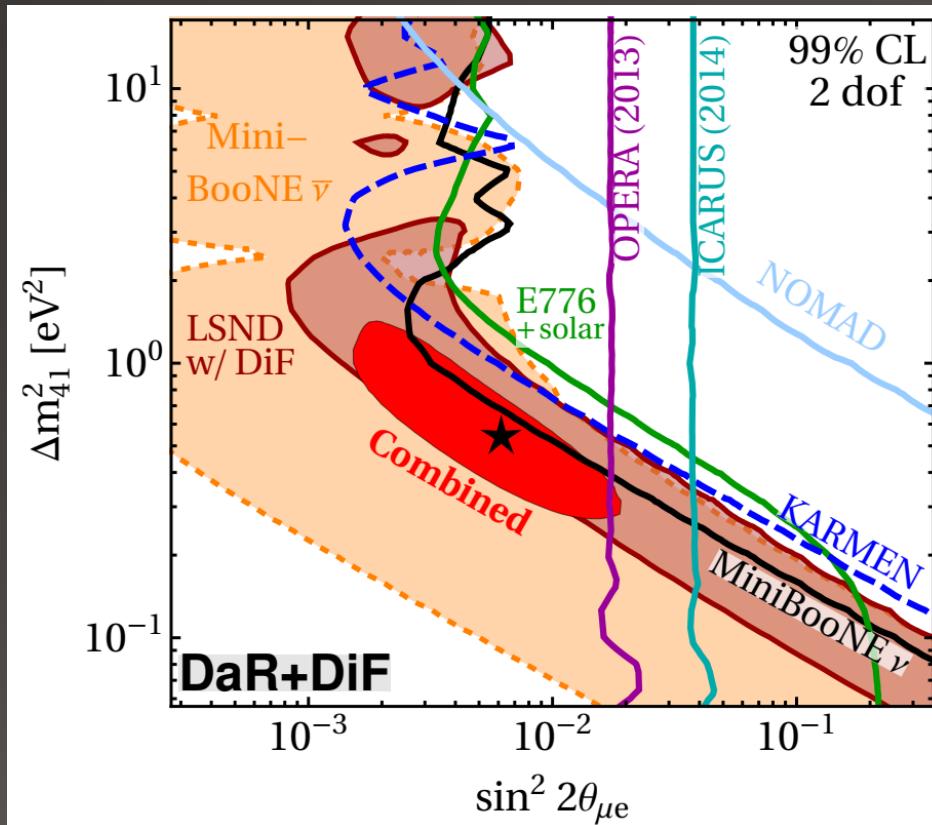
- LSND 2001: Excess in $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance
- MiniBooNE 2018: Excess in $\bar{\nu}_\mu (\nu_\mu) \rightarrow \bar{\nu}_e (\nu_e)$ appearance
- Combined significance: 6.0σ

Aguilar-Arevalo et. al. (MiniBooNE), arXiv: 1805.12028

Carlos Blanco @ Topics in Cosmic Neutrino Physics 2019

Sterile Neutrinos and SBL Oscillations

$$P_{\alpha \rightarrow e, \mu, \tau} = 1 - 4 |U_{\alpha 4}|^2 \left(1 - \sum_{\beta=e, \mu, \tau} |U_{\beta 4}|^2 \right) \sin^2 \left(\frac{1.27 \Delta m^2 (\text{eV}^2) L(\text{m})}{4E(\text{MeV})} \right)$$

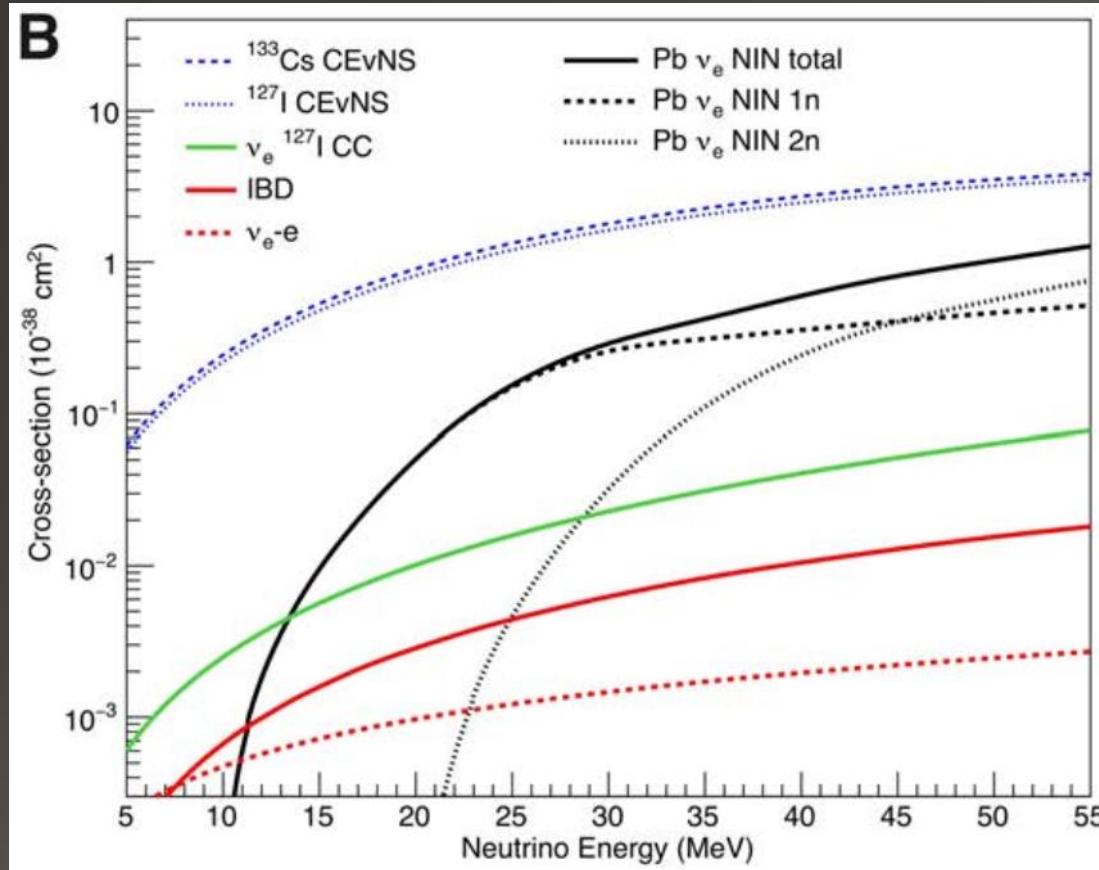


- Short baseline: no SM neutrino oscillation
- Parameter space explored only through charged currents.
- Best global fit: $\Delta m^2_{41} \approx 0.5 \text{ (eV}^2)$

$$\sin^2 (2\theta_{\mu e}) \approx 6 \times 10^{-3}$$

$$\sin^2(2\theta_{\mu e}) \equiv 4 |U_{e4}|^2 |U_{\mu 4}|^2$$

Neutral vs Charged Currents



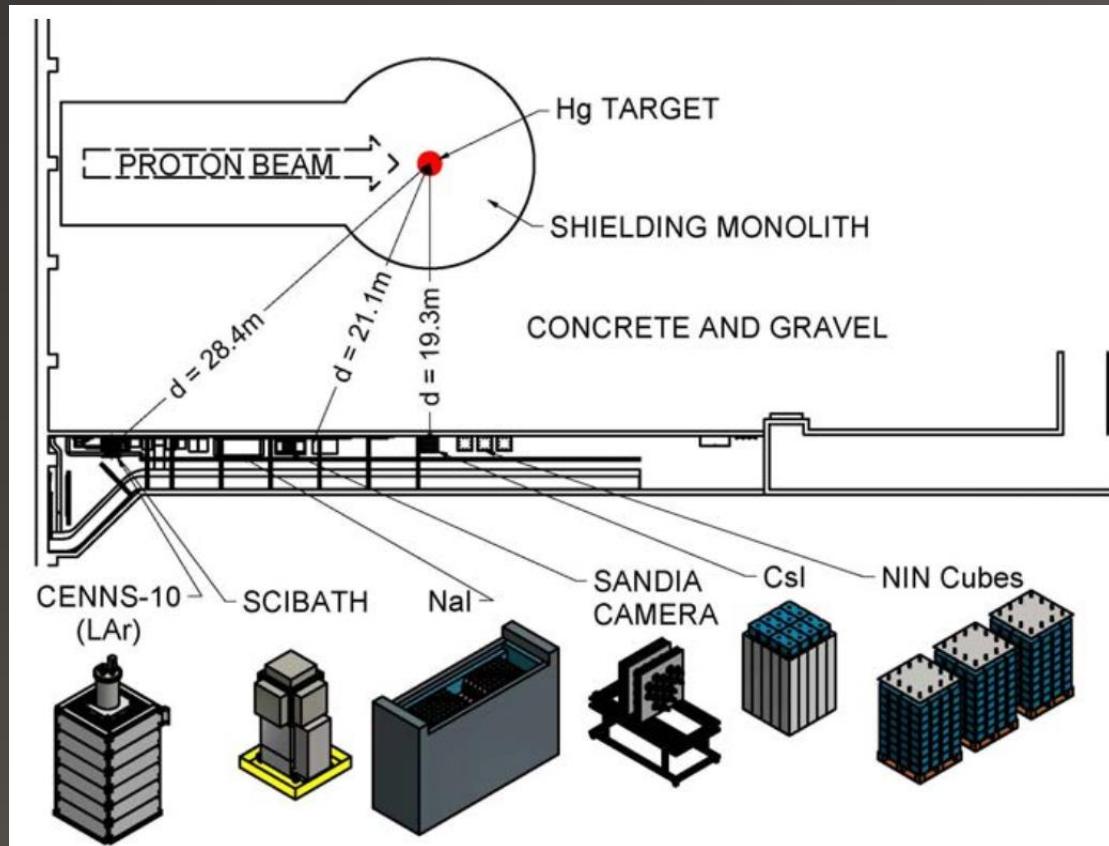
Akimov et. al. (COHERENT) , arXiv: 1708.01294

$$\left(\frac{d\sigma}{dE_T} \right)_{NC} \propto \frac{G_F^2 M}{4\pi} N^2$$

$$\left(\frac{d\sigma}{dE_T} \right)_{NC} \approx \mathcal{O}(10^2) \cdot \left(\frac{d\sigma}{dE_T} \right)_{CC}$$

- Smaller detector mass
- Very low background
- Flavor independent

Proposed Measurement



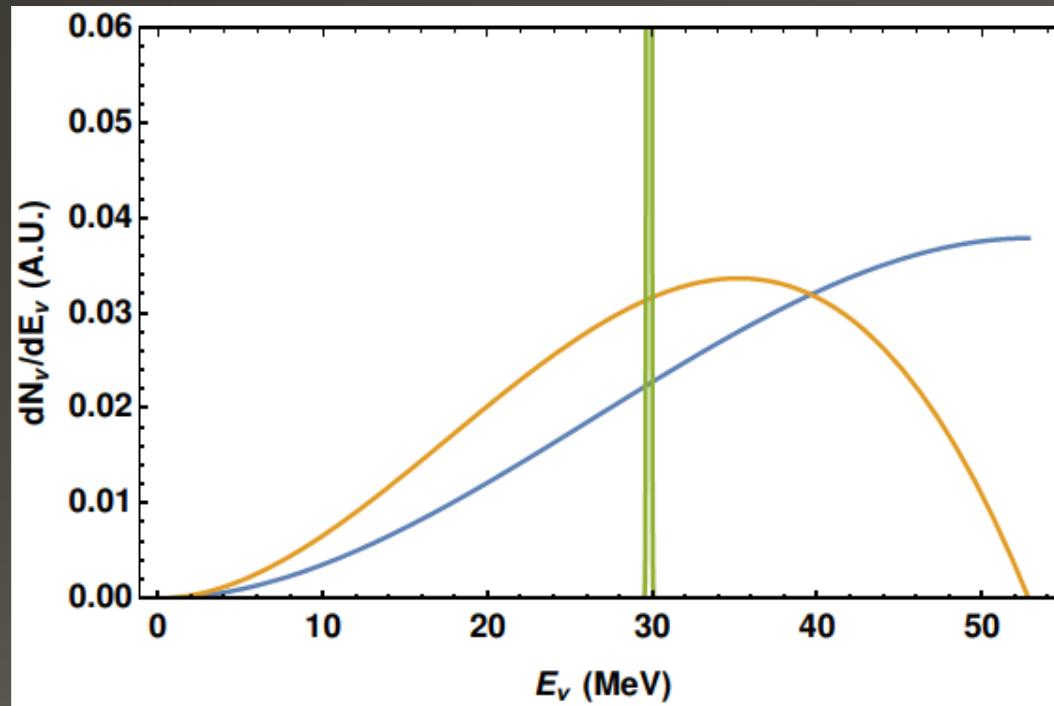
ONL S.N.S. schematic - Akimov et. al. (COHERENT) , arXiv: 1708.01294

- 100 kg CsI over 10 years
- Baselines: 20 and 40 meters
- Pulsed π -DAR spallation source
(e.g. the Spallation Neutron Source)
- 1 GeV protons @ 60 Hz : $L_o = 4 \times 10^{23} \text{ yr}^{-1}$
- Using timing and multiple baselines reduces uncertainties & increases sensitivity to short baseline oscillations.

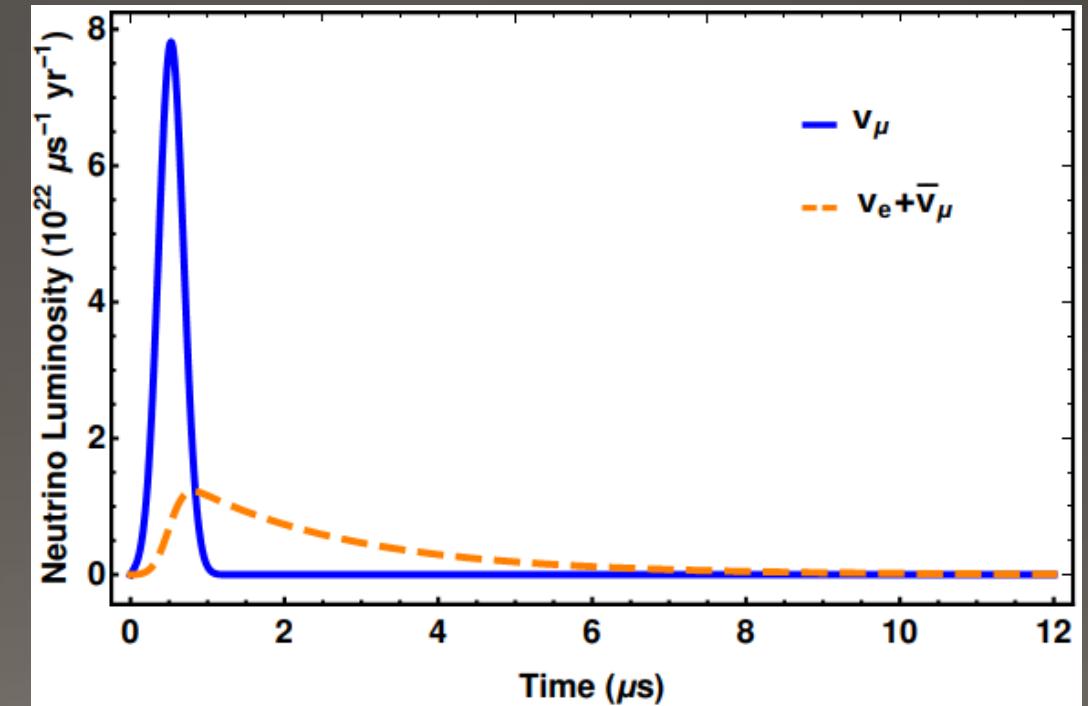
Spallation π -DAR sources

$$\pi^+ \rightarrow \mu^+ \nu_\mu \rightarrow e^+ \nu_e \bar{\nu}_\mu \nu_\mu$$

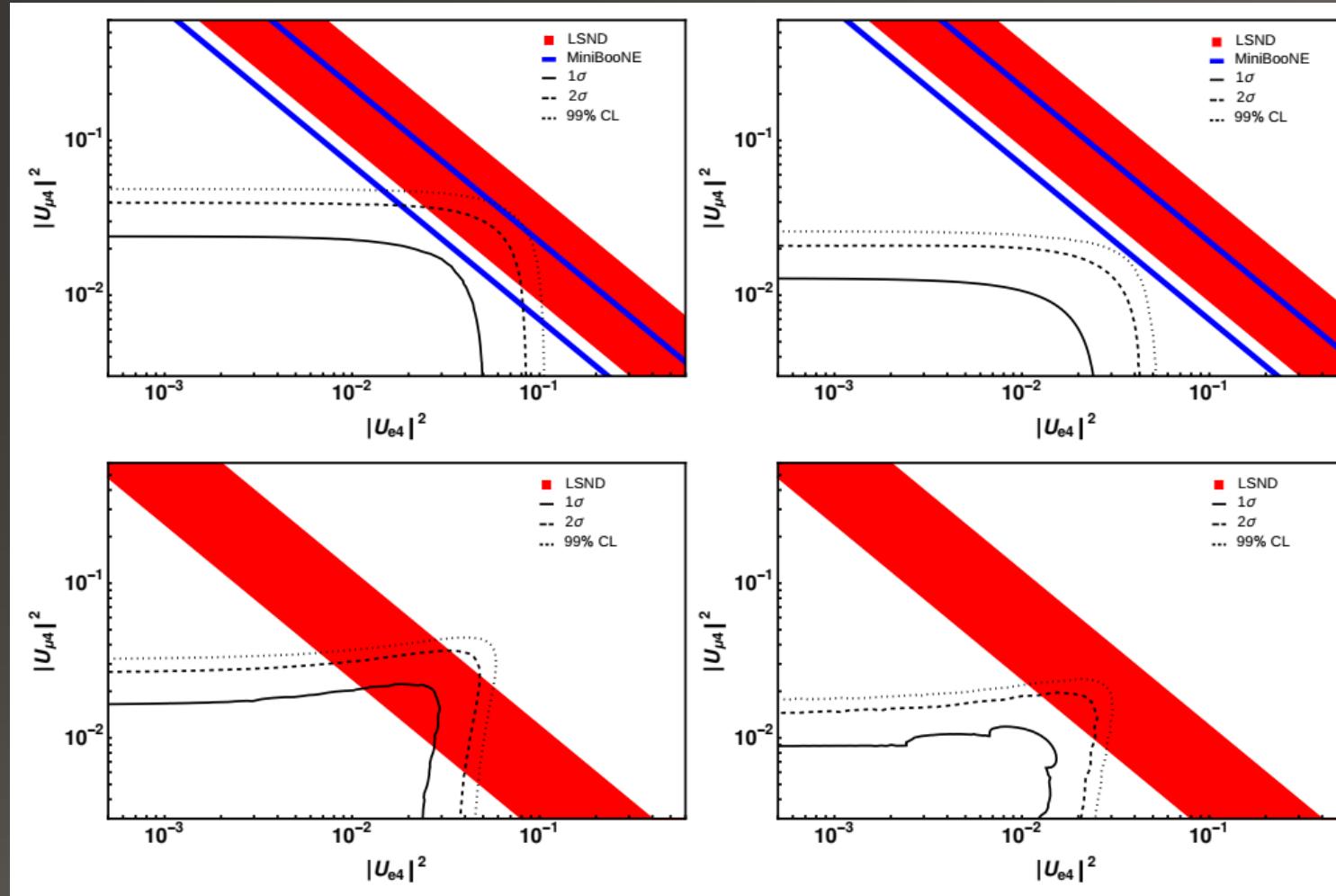
~0.026 μ s ~2.197 μ s



$$E_{\nu_\mu} \approx 30 \text{ MeV}$$



The Importance of Timing

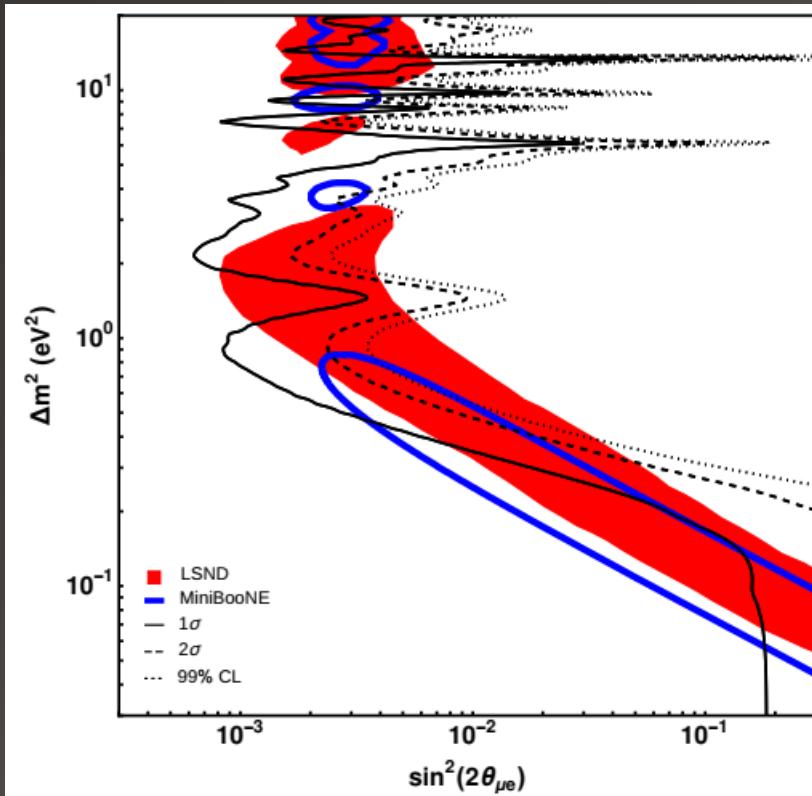


- Timing information allows for separation of neutrino flavors.

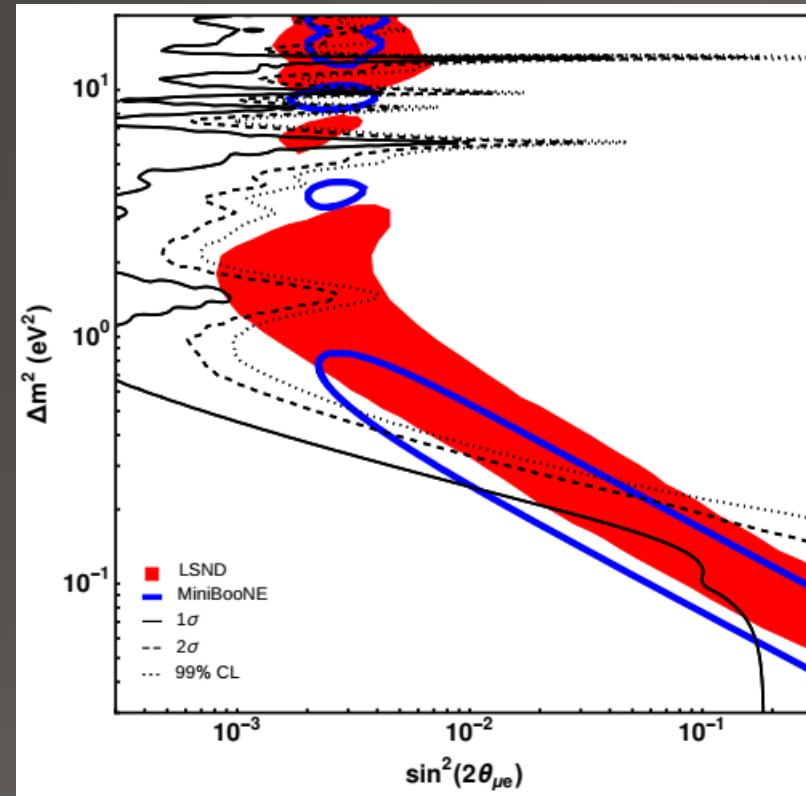
- Upper frames:
 $\Delta m_{41}^2 = 0.55 \text{ eV}^2$

- Lower frames:
 $\Delta m_{41}^2 = 1.3 \text{ eV}^2$

Sensitivity to Sterile Neutrinos



3 year total exposure @ 20 and 40 meters



10 year total exposure @ 20 and 40 meters

- Equal time of exposure at each baseline
- Exclude most of preferred parameter space @ 99% CL

Future Prospects

- Bigger detector masses are possible since CsI is inexpensive.
- Cooling could give better performance.
- Higher flux sources decrease required exposure time.
- Considering sources with complementary neutrino flavor profiles.
- Similar setups/analysis could constrain NSI, DM, cross section uncertainties.

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Summary

- LSND & MiniBooNE anomalies can be explained by sterile neutrinos.
- CE ν NS cross section is much higher than CCQE at MeV energies.
- Pulsed Pion-DAR sources provide excellent timing and energy profiles.
- Timing information gives important flavor discrimination.
- Flavor discrimination could disentangle $|U_{\mu 4}|^2$ from $|U_{e 4}|^2$.
- 1000 kg y of CsI could probe most of the best-fit parameter space.
- Small scale experiment probing “high” energy BSM physics.

Extra Slide 1

Experimental Parameter	Benchmark value
Total Systematic Uncertainty	28%
B_{ss} (Steady State Background)	Characterized -> Negligible (Timing helps a lot)
B_{on} (Beam On Background)	1.45×10^{-10} counts/kg/ μ s (10x < than COHERENT)
E_T threshold	Sigmoid: 0% @ 2.5 KeV and 100% @5.0 KeV